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Association of Adverse Birth Outcomes with Maternal Exposure to Nitrate in Private Well Drinking Water: An Action Plan for Prevention

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Abstract

Goal: The goal of the capstone project is to collect information required to develop an action plan focusing on minimizing exposure to nitrate in pregnant women, which, if implemented, can either prevent or reduce adverse health outcomes associated with nitrate exposure in utero.

Objective: The capstone project objective is to gain a better understanding of what programs to prevent exposure to nitrate from private well drinking water in pregnant women are already in place throughout the United States; to identify any areas of improvement in these programs; and to utilize this information to create a unique action plan in Scotts Bluff County, Nebraska.

Methods: Using information on needs, tactics, and current resources from Scotts Bluff County, NE; information on other state health department programs; and personal research on the topic, an action plan was developed**.** The information includes details on various programs throughout the United States; unique details of the current situation in Scotts Bluff County, NE; and characteristics of various programs implemented regarding this issue. This information was collected through personal interviews with individuals from these organizations and through an online search. Then, common themes were identified, summarized, and an action plan created.

Impact: Because exposure to nitrate in utero can be detrimental to fetal health, it is important to gain a better understanding of current exposure prevention programs, including any areas of improvement. With this understanding, as well as an understanding of specific contexts of each program, an action plan for prevention of exposure in pregnant women can be developed and ultimately implemented in counties where needs are established, such as Scotts Bluff County, NE.

Introduction

Placement Site: The placement site is the Xenobiotics Laboratory at the University of Nebraska-Lincoln (UNL). The Xenobiotics Laboratory is part of the School of Natural Resources. Part of the mission of the School of Natural Resources at UNL is to "combine interdisciplinary approaches and disciplinary excellence; address complex natural resources, environmental, and human issues; provide innovative outreach to citizens and stakeholders; and provide a quality academic experience for students" (School of Natural Resources, 2018).

Issue Being Addressed: The possibility of adverse birth outcomes associated with maternal exposure to nitrate in drinking water is addressed through the creation of a unique action plan for Scotts Bluff County that considers any areas of improvement in current programs for this issue throughout the United States.

Importance of Proposed Project: Prenatal exposure to nitrate in drinking water is associated with increased incidence of spina bifida, limb deficiency, cleft palate and cleft lip in offspring (Brender et al, 2013). About 5% of ingested nitrate is converted to nitrite (Lyon, 2010). In an acidic environment, like that of the stomach, nitrite can react with secondary amines, such as the herbicide atrazine, to form nitrosamines such as *N*-nitrosoatrazine or other *N*-nitroso compounds (NNAT; Krull, 1980; Ward, Jones, Brender et.al, 2018). These are found to be teratogenic in animal studies (Inouye et.al, 1978; Platzek et.al, 1983). Agrichemical spikes in surface water are correlated with higher risk of birth defects in offspring of mothers reporting last menstrual period during these spikes (Winchester et.al, 2009).

Currently, there are standards for agrichemical contaminants in public water systems (PWS) through the Safe Drinking Water Act (SDWA). The SDWA includes standards for acceptable levels of some agrichemicals in PWS. The maximum contaminant level for nitrate is

10 mg/L (Office of Ground Water and Drinking Water, 2018). But, these standards are only for PWS, not for private wells. Because of this, comprehensive interventions addressing private well water and minimizing exposure to these contaminants in utero are vital.

Through my Service Learning activities, I helped the Xenobiotics Laboratory on a research project studying the effects of exposure to the combination of nitrate and agrichemicals during pregnancy. This capstone project, including the finished action plan, relates to the research done in the Xenobiotics Laboratory.

Literature Review: Brender, et al., 2013 found an association of maternal nitrate exposure and neural tube defects, limb deficiency, cleft palate, and cleft lip to be significant. Huber, et al., 2013 similarly found an association of maternal exposure to nitrate and nitrite and neural tube defects, oral clefts, and limb deficiencies to be significant. In reviews done by Manassaram et.al, 2006 and Brender & Weyer, 2016, an association of maternal exposure to nitrate and nitrite and possible various birth defects (i.e. neural tube defects, congenital cardiac defects, premature birth, low birth weight, CNS defects, congenital malformations) was found to be significant (Arbuckle et.al, 1988; Bukowski et.al, 2001; Croen et.al, 2001; Dorsch et.al, 1984). Winchester et.al, 2009 focused on the association between atrazine and other pesticides in surface water and birth defects, specifically in a spike of atrazine and other agrichemical (pesticide) levels, and found a correlation of higher risk of birth defects in offspring of mothers reporting last menstrual period during the spike.

Although the SDWA has standards for PWS, the SDWA or the Environmental Protection Agency (EPA) in general does not have standards or regulations for private well water (United States Environmental Protection Agency, 2018). According to the EPA, “private well owners are responsible for the safety of their water” (United States Environmental Protection Agency,

2018).. This indicates the importance of intervention, especially in vulnerable populations, such as pregnant women. The Centers for Disease Control and Prevention (CDC) indicates that pregnant women, and other vulnerable populations, are more at risk of adverse health outcomes after exposure to nitrate contaminated water (Centers for Disease Control and Prevention, 2012).

The literature indicates an association between exposure to nitrate and birth defects as well as an association between other agrichemicals and birth defects. Additional research on current programs throughout the United States focusing on prevention of prenatal exposure to contaminants in private well water would provide useful information and would identify specific action needed to help decrease the risk of adverse birth outcomes in vulnerable populations, such as those in Scotts Bluff County, Nebraska.

Descriptive Statistics of Scotts Bluff County, Nebraska: The population of Scotts Bluff County is about 40,000. During 2015, there were 500 live births, with the trend indicating that the number of live births continues to increase, through comparison of previous years (Nebraska Department of Health and Human Services, 2015). In 2015, there were 31 birth defects, totaling 6.2% of live births in the county. In the four years preceding 2015 (2011-2015) there were a total of 117 birth defects, totaling 4.8% of live births (NDHHS, 2015).

Scotts Bluff County, Nebraska Situational Analysis: According to the United States Geographical Survey (USGS) Groundwater Watch, Scotts Bluff County has the most active water wells, mostly domestic wells (USGS, 2016; Nebraska Department of Natural Resources, 2018). The majority of these wells are either hand dug wells, or driven wells (USGS, 2016). These types of wells tend to be shallower. Shallow wells are considered to be less than 50 feet below the land surface, while deep wells are considered to be greater than 50 feet below the land surface (Spalding, Burbach, & Exner, 1989). Because of this, most of the wells in Scotts Bluff

County draw water from aquifers that are closer to sources of nitrate contamination (Environmental Protection Agency, 2017).

Additionally, there are a large number of farms in the county, with a 32% increase in number of farms from 2007 to 2012 (USDA, 2012). Because of the higher amount of wells and agriculture, nitrate contamination in private well water is possible throughout the county.

Methods

Research Question: Are there areas of improvement in current programs for prenatal nitrate exposure in private well drinking water across various health departments in the United States? What implication does this have for the development and implementation of an action plan for rural Scotts Bluff County to address these issues?

Study Design: This is a qualitative study that gathers qualitative information from a variety of sources. Specifically, this is an action research study design because I sought information from individuals that deal with water contamination in order to solicit potential action.

Study Population: The study population is Scotts Bluff County, through communication with the director of the Panhandle Public Health District, Kim Engel.

Information Source: The information required for the creation of the action plan was obtained from personal research done on current applicable programs focusing on prenatal nitrate exposure and interviews with specific individuals in the Connecticut, New Hampshire, and New Mexico health departments. The information about Scotts Bluff County was collected from the director of the Panhandle Public Health District.

Information Collection Method: I collected initial information on applicable programs across the country through various online searches of health department websites. I determined

that Scotts Bluff County has a need for an action plan by online searches of all the different counties in Nebraska. The director of the Panhandle Public Health District, the health department over Scottsbluff County, was then interviewed.

Upon investigation of all of the applicable health programs across the country, 13 different programs are relatable to the issue. Of these 13 programs, three are the most applicable to Scotts Bluff County. Individuals from these three health departments were interviewed and asked questions about their unique programs, how they came about, and how they function. These health departments are part of Safe Watch, or Safe Water for Community Health. Safe Watch is a program through the CDC that helps health departments reduce harmful exposures from wells and other private water systems through the improvement of already existing programs (CDC, 2018).

Statistical Methods: A qualitative analysis looking at the gaps that exist, and what ways are most efficient to help the population, through finding common themes, was reformed from the interviews conducted. This analysis was used to summarize the information gathered from each individual questionnaire and my personal research.

Results

Magnitude of the Problem in Nebraska: In Nebraska, the EPA estimates that 17% of the state area groundwater is contaminated with nitrate >5 mg/L (Environmental Protection Agency, 2017). Descriptive statistics of each of the nitrate related adverse birth outcomes in Nebraska, including spina bifida; cleft lip; and limb defects, follow. The average annual number of cases of spina bifida is 18, with a birth prevalence of 6.9; the average number of cases of cleft lip is 27 with a birth prevalence of 10.9; and the average number of cases of upper and lower limb defects is 11, with a birth prevalence of 4 (National Birth Defects Prevention Network, 2012).

Review of the Literature: Sifting through the research on nitrate contamination, I found that nitrate can penetrate through soil and remain in groundwater for decades (Manassaram, Backer & Moll, 2006). According to the United States Geological Survey, groundwater is the source of more than 50% of drinking water supplies and 96% of private water supplies in the United States (Manassaram, Backer & Moll, 2006). Private wells tend to be shallower and closer to sources of nitrate contamination, such as agricultural run off, putting those that get water from a private well more at risk of nitrate exposure (Manassaram, Backer & Moll, 2006). Thus, it is important for private well owners to regularly test their water, especially those that live by areas of intensive agriculture (EPA, 2018).

Well testing is a necessary way to determine the quality of well water and the potential water treatment. Because responsibility is placed on the well owners to ensure adequate water quality, private well stewardship or "voluntary actions well owners take to protect local groundwater resources" is an important action taken for protecting those that rely on private well water (Imgrund, Kreutzwiser, & Loe, 2011). While many aspects are included in well stewardship (proper well construction; regular water testing; maintenance and inspection of the well; source water protection; and water treatment) water testing is one of the most important because of the information it provides on water quality (Imgrund, Kreutzwiser, & Loe, 2011; Simpson, 2004; United States Environmental Protection Agency, 2007). The information it provides can help individuals be more motivated to treat their water, especially if it is deemed necessary to treat the water and there is a perceived problem, such as the associated risk in pregnant women, accompanied with that knowledge (Imgrund, Kreutzwiser, & Loe, 2011).

As indicated by Imgrund et al. (2011), water treatment is also included in the "private well stewardship" and is thus the responsibility of the private well owner. Nitrate can be

removed successfully from water through various filtration measures including nitrate specific ion exchange, distillation, and reverse osmosis (CDC, 2015; University of Nebraska-Lincoln, 2000). Therefore, if an unhealthy amount of nitrate is found in private well water, it is up to the well owner to have the water treated. The CDC recommends contacting local health departments for treatment recommendations (CDC, 2015).

Reverse osmosis filtration is the most efficient and cost effective way to filter out large particles such as nitrate (Filter Water, 2018). It can be inserted into an entire house's water system and works by removing most minerals, metals, and many organic impurities (Filter Water, 2018). Similarly, nitrate-selective ion exchange filters are cost effective, but require care to replace filters before it becomes too saturated. These are not as efficient as reverse osmosis filters, but still effectively remove the nitrate contamination. Both of these methods cost the home owner about $140 to install (Filter Water, 2018).

There are barriers to individuals testing their private well water, and thus treating their water. These barriers include complacency, inconvenience, cost, lack of knowledge, lack of a perceived problem, lack of perceived risk and ability, and attitude (Imgrund, Kreutzwiser, & Loe, 2011; Flannagan, Marvinney & Zheng, 2015). Another study done looking at the influences that affect domestic well water testing, similarly found that better educated and higher income households are more likely to test their water (Flannagan, Marvinney & Zheng, 2015).

Scotts Bluff County: Scotts Bluff County has implemented some measures to help decrease risk of exposure to vulnerable populations, such as providing free water testing kits through nitrate testing weeks in 2011 and 2013 (North Platte Post, 2013). The free private water testing lasted for 5 days during the Scotts Bluff County Fair in the summer of both of those years (North Platte Post, 2013).

Applicable Health Programs: The 13 programs that are related to prenatal health as well as private well water testing for general contaminants are found in Table 1. The health departments where each of the programs are found is listed in one column with the applicable program described in the other column.

Table 1—Programs Related to Education During Prenatal Care (AZ,AK, KY, National, NE, NJ, NY, SC, WY) and Programs Related to Private Well Water Testing (CT, LA, NH, NM) Across the United States

State Health Department	Program
Arizona	Power me AtoZ—A program that provides information for pregnant women and those that have just had a baby. Includes information on what to know and what to avoid (Arizona Department of Health Services, 2018).
Arkansas	Maternity Program—A program that focuses on prenatal services and prenatal education regardless of if the participants are able to pay. It functions through using local health units. (Arkansas Department of Health, 2017)
Connecticut (Safe Watch)	Educational Media Campaign—A campaign that ran in 2017 that promoted private well testing (Northeast District Department of Health, 2017).
Kentucky	Kentucky Infants Safe and Strong—An award program that recognizes hospitals and clinics taking steps to implement practices to reduce infant mortality (Kentucky Cabinet for Healthy for Health and Family Services, 2017).
Louisiana (Safe Watch)	Louisiana Private Well Owner Network—A network made for owners of private wells to help with their drinking water needs providing them with specific information on private well water (Louisiana Department of Health, 2018).
National	Text4Baby—A network of partners that provide information about pregnancy and the baby's first year through a convenient text method (Wellpass, 2018).
Nebraska	Child Health Information Helplines— Information helpline that provides information and referrals for health and social services to families. Answers questions on prenatal care, child development, Medicaid, and any other questions they may have (Nebraska Department of Health and Human Services, 2016).

Nebraska	Home Visitation Program— Following the Healthy Families America curriculum, nurses visit homes where they 1. Assess individual Family needs. 2. Provide education and support and 3. Refer families to needed resources. (Nebraska Department of Health and Human Services, 2018)
New Hampshire (Safe Watch)	*Be Well* Informed Guide—A guide that is designed to help private well owners understand water test results and provide information on contaminants (New Hampshire Department of Environmental Services, 2018).
New Jersey	Maternal and Child Health Consortia— Private nonprofit organizations come together to provide education and coordination or perinatal services (New Jersey Department of Health, 2018).
New Mexico (Safe Watch)	Water Fair and Water Quality Program—Annual water fairs are held that offer free private well water testing and opportunities to talk with experts about water quality (New Mexico Environment Department, 2018).
New York	Welcome to Parenthood: A Family Guide—A guide used to answer any questions of pregnant women and new families (New York State Department of Health, 2013).
South Carolina	Nine Months to Get Ready Booklet—A booklet that gives detailed information related to pregnancy (S.C. Department of Health and Environmental Control, 2018).
Wyoming	Women and Infant Health Program— A program that, through the Maternal and Child Health Unit, performs a needs assessment to determine WY's health priorities for women and infants (Wyoming Department of Health, 2018).

Interview—The Health Departments: I interviewed individuals from three of the 11 state health departments detailed in Table 1. These three programs focused on the promotion of private well water testing for different contaminants, including arsenic and nitrate. They also focused on providing relevant information to the target population. I asked questions based on each individual program, where it originated, and what processes were necessary for it to be successfully implemented. The specific questions and answers are illustrated in Table 2.

Table 2—Interview Results from Three Private Well Testing Programs

	NM Water Fair Program Testing for Nitrate *(Matthew Smith from New Mexico Environment Department (NMED))*	**NH Be Well Informed Guide** *(Pierce Rigrod and Cynthia Klevens from NHDES Groundwater and Drinking Water)*	**CT Educational Campaign Testing for Arsenic** *(Private Well Program, Connecticut State Department of Public Health)*
1. What led to the development of this initiative?	-It was found that a more comprehensive Water Fair Program was needed to reach more well owners and to provide educational opportunities.	-Through a statewide survey, private well owners have demonstrated that a high percentage of them were not selecting right treatment to remove contaminants, such as arsenic; iron; and manganese.	-Most individuals don't test their water -Those that do test only test when they purchase a new home. -Done to try to have more individuals testing their water.

2. How did you arrange funding?	-Application for an EPA grant.	-One-time Funding came from CDC grant awarded to the Planning, Protection and Assistance Section at NHDES. -Operating funds continue to maintain the guide.	-Applied for a CDC grant.
3. What challenges did/do you face with this initiative?	-It is hard to get the word out about the Water Fairs. They are only scheduled one to two months in advance.	-Some initial industry hesitation. -Keeping Be Well Guide current will be challenging over time.	-Trying to reach the target audience. -Figuring out different media platforms to reach different audiences
4. How have you measured success?	-Measured by the number of private well owners that participate in the water fairs. -Deemed successful if at least 20 private well owners participate in each water fair event.	-Track the number of people entering data into the application.	-The number of social media messages (Facebook, Pandora, etc.) displayed. -Google analytics to see how many visited the website.
5. How do you sustain this initiative? OR Would you do this campaign again?	-It has proven to be very popular with the general public. -NMED receives numerous requests for water fairs.	-In their department they have technical IT resources and experienced engineering knowledge.	-Would absolutely do the campaign again. Only if they "had the money."

Interview—Panhandle Public Health District Director: After the information from the state health department interviews was collected, I then focused on Scotts Bluff County. The interview with the Panhandle Public Health District Director, Kim Engel, consisted of questions asking what interventions have already been done, what the specific needs of the county and public health district are, what can be done, and what resources are available for the public health district. The information is summarized in Table 3.

Table 3—Interview with Panhandle Public Health District Director

What has been done	**What is possible**
-Scottsbluff County joined Panhandle when previous health director resigned. With previous department, there was a policy that required new homeowners to test their water wells for nitrate. -Nitrate well water testing information—through UNL. - North Platte Natural Resource District (NRD) frequently does free well water testing -Scottsbluff County has done free well water testing in the past.	-Educational campaign through various social media platforms including a website creation. -The Panhandle Public Health District is accustomed to running media campaigns and has a very good relationship with media department. -They have a good home visitation program and could use this to amplify the educational campaign.
Resources	**Needs of Scottsbluff County**
-Potential CDC grant -Collaboration with North Platte NRD -Various expertise within the district, including Health Promotion Specialist and the Healthy Families America (Home Visitation Program) Director	-She indicated that there has been higher amounts of nitrate in the Scotts Bluff County water in the past -Not a significant amount of funding in the Environmental Department. Would need funding.

Common Themes: Once all of the information was gathered, it was analyzed and common themes described. These are illustrated in Table 4.

Table 4—Comprehensive View of all the Applicable Programs (Education During Prenatal Care and Private Well Water Testing): Common Themes Related to Specific Aspects of Each Program

Type Of Intervention	Focus of Intervention	Funding/Resources
-*Many interventions included a booklet, guide or the creation of a website. -These are available to the participants through the internet. -**Successful programs provide convenience and low cost	-*Education **-Providing what is desired from the program directly to the participants (Water Fair and Water Quality Program) -*Focusing on marketing of the information.	-Media/Marketing Agencies -Environmental Departments/Resources Districts -Funding from government grants

*Education Related Theme
**Convenience Related Theme

Discussion

Education related themes are indicated with an asterisk in Table 4. Because education of the specific topics for each program is prevalent among each of the programs, education about maternal nitrate exposure and private well water testing will play a part in the action plan. This will be done by utilizing the already existing Home Visitation Program in Scotts Bluff County. There is evidence that Home Visitation Programs are effective and there are a number of benefits to these programs, both short and long-term. These include increased use of health and community resources, improved nutrition, increased attendance at childbirth classes, and higher development quotients in infants that were visited (American Academy of Pediatrics, 1998).

Considering the common theme of convenience for the participants found (indicated by double asterisks), the Internet was used in the action plan. According to Broadband Now, 100% of residents in Scotts Bluff County have access to fixed wireless Internet access (Broadband

Now, 2018). Online health education has been found to be associated with improving health behavior change in individuals. A meta-analysis of 85 Internet health interventions showed that online interventions had a statistically significant effect on health behavior change (Webb, Joseph, Yardley & Michie, 2010).

It is important to consider these themes to create a comprehensive program to address the needs and resources of the county as a whole in addition to the participants.

Action Plan: The action plan begins with an analysis of the current situation in Scotts Bluff County. Then, the Be Well Water Program is described. This program includes the creation of a website (Be Well Water website) that has information on private well water testing and the dangers of nitrate during pregnancy. Then, over the course of the year, using the already existing Home Visitation Program, this website will be promoted by incorporating it into the curriculum given by the Parent Coaches. In the middle of that year, a free well water-testing week will be held during the Scotts Bluff County Fair. Participants will bring a sample of their water to the fair and will have it tested on site. This testing week will be promoted on the already created website and through the curriculum of the Home Visitation Program.

The goal of the program is to, by January 2021, increase the number of informed (defined as understanding the importance of well water testing and the dangers nitrate poses during pregnancy) pregnant women by 25%, determined by comparing a baseline survey to a post intervention survey given to pregnant women through the Home Visitation Program.

Barriers to private well water testing are addressed through the action plan. The barriers addressed include lack of knowledge, monetary cost, and convenience. Lack of knowledge is addressed by providing the target population with factual information of the problem. Cost and convenience are addressed by providing free water testing during the program and by providing the information free of charge through the website. Table 5 is the action plan in its entirety.

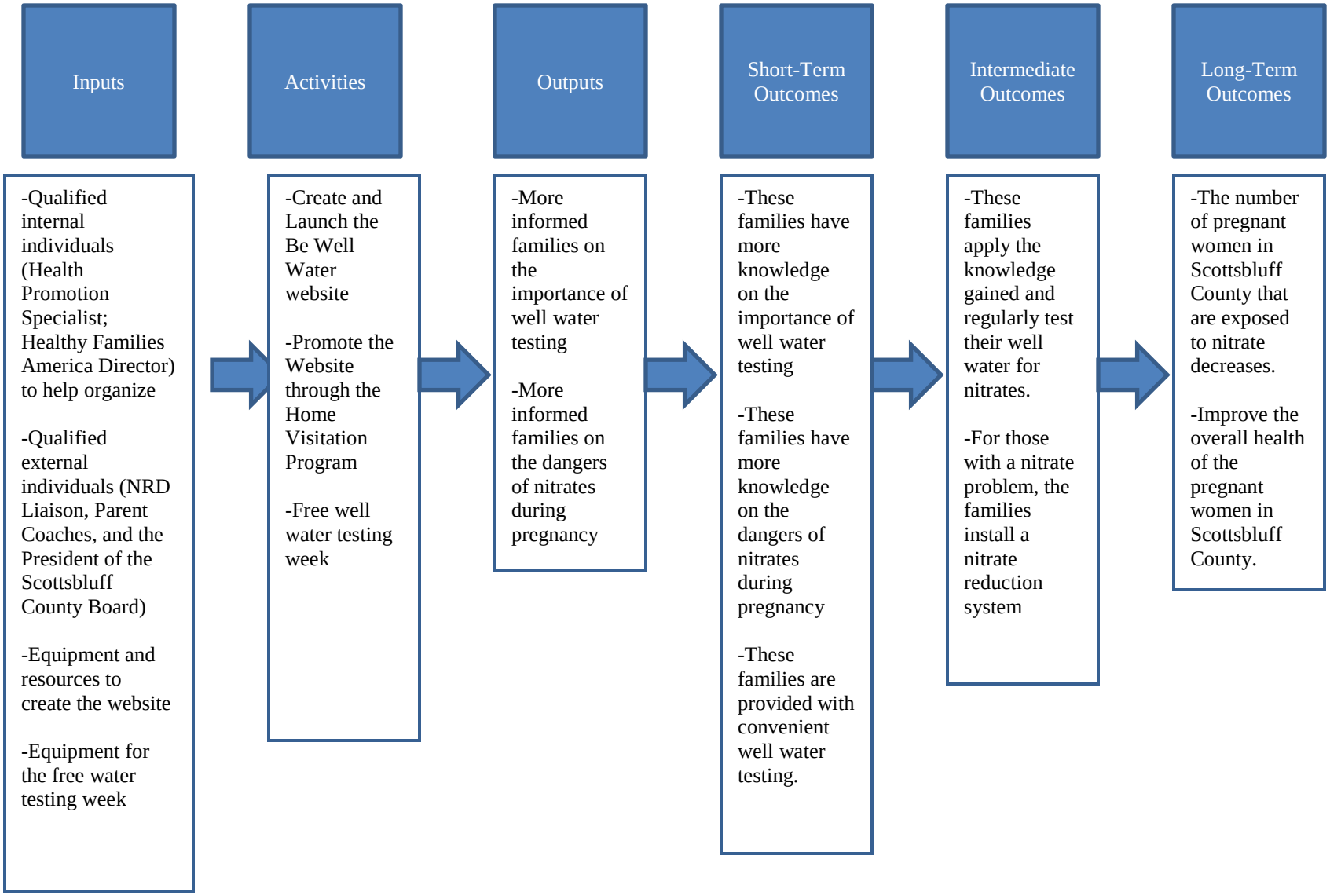
Table 5—Action Plan for the Be Well Water Program

Activity	**Resources**	**Anticipated Result**	**Budget/Cost**	**Target Date**
Apply for CDC grant; secure funding	Time; Health Promotion Specialist from the Panhandle to apply and oversee process	Funding	$2,500 for the application and for the time of the Health Promotion Specialist	February 2019
Collaborate with the Healthy Families America (Home Visitation) Director to establish ability to participate in the intervention	Time; the Healthy Families America Director	Agreement on participation	$5,000 for the time of the Healthy Families America Director	April 2019
Create and administer the baseline survey to the Home Visitation Program private well owner participants.	Time; the Healthy Families America director; each of the Home Visitation Parent Coaches	Information on basic understanding of private well information as well as individual internet access information.	$2,500 for the time of the Home Visitation Parent Coaches (Healthy Families America Director compensated above)	July 2019
Collaborate with the NRD and create content for the website	Time; Health Promotion Specialist; An NRD Liaison to collaborate with	All inclusive content for the website (Private well water testing, contaminant information for target population)	$0 (Health Promotion Specialist compensated above)	August 2019

Create and launch the Be Well Water website	Time; Health Promotion Specialist from the Panhandle to coordinate the website creation; Funding from CDC grant to create website	The Be Well Water website fully launched	$15,000 to create website (Health Promotion Specialist compensated above)	December 2019
Promote the Be Well Water website through the Home Visitation Program	Time; Healthy Families America Director; Home Visitation nurses	Successful promotion of the Be Well Water Website	$0 (Healthy Families America director and Parent Coaches compensated above)	December 2020
Collaborate with the NRD and the Scottsbluff County Fair to organize a free well water testing week for the families in the Home Visitation Program	Time; Healthy Families America Director; NRD Liaison; President of the Scottsbluff County Board	Organized plan of the free well water testing week.	$0 (Healthy Families America director compensated above)	July 2020
Promote the free well water testing week in target population and do the free well water testing week	Time; Healthy Families America Director; President of the Scottsbluff County Board	Sufficiently promoted well water testing week	$500 to participate in the fair (Healthy Families Director compensated above)	August 2020
Administer and analyze the post-intervention survey	Time; Healthy Families America Director; Home Visitation nurses; Statistician	-Data on any understanding of private well information -Any change of understanding in the target population	$2,500 (Healthy Families America director and Parent Coaches compensated above)	February 2021

Evaluation Plan: In order to evaluate the proposed outcome of this program, an evaluation plan was created. This begins with a logic model of the program.

Logic Model of the Be Well Water Program



Evaluation Design: A one-group design will be used simply because it is difficult to either have a control group or another group to compare to those in the Home Visitation Program. It is easier to compare these groups to themselves at different times using the pre-test and post-test design. In this evaluation, the data collected after the implementation of the Be Well Water Program is dependent on data taken from before the implementation in order to perform a complete comparison.

Measurement of Outcomes: The outcomes of this program will be measured through a survey given to the families that own a private well participating in the Home Visitation Program before the implementation of the program as well as after the program is complete. A sample of the survey is included in the Appendix. As the surveys are completed, the mean answers will be collected for each question, both in the pre-test and in the post-test. To compare the mean answers of each question between the two groups, a paired samples t-test will be used.

Feedback from the Panhandle Director: The director of the Panhandle Public Health District went through the action plan and assessed it according to the county's needs. She agreed that the Scotts Bluff County Fair is a good idea to provide free water testing.

She thought that free water testing kits could be distributed to each of the homes that participate in the Home Visitation Program in addition to providing free water testing during the Scotts Bluff County Fair. She also thought that the website and the free well water testing week could be promoted through various other means besides the Home Visitation Program. These include garage sale sites, the Panhandle Public Health District Facebook page, and through the Women's Center.

The rest of her feedback was on the budget. The website would only cost about $500 to create, rather than $15,000. Because of this, she thought some of the money originally allotted to

the website could go to paying for the water testing at the fair, free water testing kits to be distributed, and possible treatment of water if deemed necessary.

Contributions to Public Health: This research project provides a basis for potential change in policy and interventions throughout the state of Nebraska. The research specifically provides a succinct summary and a list of common themes from many of the applicable interventions for this problem that have been implemented or that are being implemented currently. This provides policymakers, such as the director of the Panhandle Public Health District, with an idea of characteristics of current programs to address this problem.

The action plan sent to the director can be used as an outline and a base for any future interventions in Scottsbluff County. This has the potential to ultimately help change public health policy and practice not only in Scottsbluff County, but also in the whole Panhandle Public Heath District, which encompasses 12 counties, if implemented.

Suggestions for Future Projects: This research project brought to light the fact that few programs specifically target nitrate exposure in utero through private well water. There are programs that target well water testing in the general private well owner population, as well as programs that target pregnant women and prenatal information, but there are not many programs combining the two.

Therefore, a suggestion for a future project would be to do more international research to understand not only what is being done in the United States, but to understand what is being done in other countries for this issue. This would give a broader idea of what can be done. Furthermore, it would be beneficial to create an action plan that focuses on the combination of private well water testing and prenatal exposure to nitrate, on a larger scale, perhaps statewide or

regional. This could potentially help more pregnant women and families understand the importance of this issue.

Conclusion

This research revealed the gap in available programs for pregnant women and the importance of private well water testing for nitrate. The programs that have been implemented and are being implemented target one aspect or the other. When looking at each of the programs individually, then comparing and contrasting them, common themes were found in the implementation. These common themes include education and the use of convenient media tools, such as booklets; guides; and websites to deliver the information. Using these common themes, as well as the individual needs of Scotts Bluff County, an action plan was created.

This research is preliminary. It addresses the lack of interventions present throughout the country for this issue and highlights the fact that more research and projects are needed to fully address the problem.

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Appendix

Measurement Outcome—Survey:

Rate how well you understand each of the following statements with 1 being not very well and five being extremely well. (Circle the number)

1. I understand that there is the possibility of the presence of various contaminants in my well water.

1 2 3 4 5

2. I understand the extent to which these contaminants are monitored by the EPA.

1 2 3 4 5

3. I understand that nitrate can be found in my private well water.

1 2 3 4 5

4. I understand the effects nitrate can have on unborn fetuses and infants younger than six months.

1 2 3 4 5

5. I understand how to test my well water (including where to test and what I need to do).

1 2 3 4 5

6. I understand what can be done to treat my water if deemed necessary.

1 2 3 4 5

7. Have you ever had your well water tested? (Pre-test)

Yes No

8. If yes, when? _____ (Pre-test)

9. Do you plan on getting your well water tested? (Post-test)

Yes No

10. Do you have access to uninterrupted Internet? (Pre-test)

Yes No

Service Learning/Capstone Experience Reflection

Experience with the Xenobiotics Laboratory: As I spent time working with the Xenobiotics Laboratory, I learned that the research that is done in this organization takes a lot of work and a lot of time. This was something I didn't entirely expect. I expected the research project that I participated in to be complete by the time I completed my Service Learning, but it has just barely started at the end of my experience. I did not expect there to be so many different individuals working on the project within the organization, and outside of the organization. It has been a very beneficial experience for me to see how organizations, such as this one, conduct research. It is something I have not had a lot of experience in before.

SL/CE Activities: I worked directly with Dr. Martha Rhoades and Dr. Pat Shea of the Xenobiotics Laboratory on various aspects of the Birth Outcomes and Water (BOW) project. I worked on the creation of BOW website content; putting together documents for the research packets; the BOW questionnaire; and putting together a binder of packet documents. I did this both remotely and in person at UNL beginning in June and ending in November of 2018.

For my capstone project, I spent time researching various health programs throughout the United States, as well as assessing the needs of counties in Nebraska. After establishing a need in Scotts Bluff County, I personally contacted and interviewed three different individuals from three different state health departments to assess each different health program. I then interviewed the director of the Panhandle Public Health District about the specific needs and

resources in Scottsbluff County. Once this was done, I created an action plan and asked for feedback from the director.

To perform the SL/CE activities, I needed a background on research and general public health information. I also needed presentation and people skills in order to understand how to present to the collaborators of the BOW project.

Products: I aided in the creation of the Resources, Participant, and Investigator pages of the BOW website. This included writing the content, finding media for some of the pages, and helping with the edits. I also created a binder of all of the packet documents and organized the documents in the correct order. I then presented this in front of some collaborators for the project. The presentation was developed for Dr. Rhoades and Dr. Shea as well as three other collaborators for the project.

For the capstone, I created four tables with the information I gathered, an action plan, and an outcome evaluation for the proposed program.

Contributions/Strengths: I think one of my greatest contributions was my organization skills and my ability to organize the packet documents in the correct order and find any inconsistencies. I really enjoyed doing that and I think Dr. Rhoades and Dr. Shea appreciated it. This skill also carried over into my capstone project, as I was able to organize all of the research into one cohesive whole in order to create the action plan.

Challenges: The greatest challenge, for me, was having to figure out how to communicate with those I worked with, especially in times of difficulty. This had to do mostly with my Service Learning activities, but also with my Capstone activities. In the middle of my project, there was some miscommunication between my preceptor and I that caused some issues that I had to overcome. But, I addressed those by communicating with her and my committee as

best I could. I think what helped the most was communicating more with all of those involved in the experience, including my entire committee as well as Laura Vinson. It was all a huge learning experience for me, but eventually I learned that constant communication is beneficial, especially when difficulty arises.

During my Capstone project, I had a difficult time getting a hold of county health departments in Nebraska to ask for willingness to work with me. This was a challenge that I overcame by persistently trying, and eventually I was able to get a hold of somebody.

Public Health: This experience has provided me with more confidence in my public health abilities. Before this project, because I had never put what I was learning in practice, I was not as confident in my abilities. But, now that I have seen and been a part of public health in action, I feel more confident. It also helped me to realize how tough and complex it is to get many things done in public health. I didn't realize how many individuals and processes have to take part in a project. This, ultimately, helped me realize how important public health is and how we need as many capable people as possible in order to get the job done.

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